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Problematic Plant Monitoring in Tallgrass Prairie National Preserve, 2006–2018

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U.S. Department of the Interior

Natural Resource Stewardship and Science

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2006–2018

Natural Resource Report NPS/HTLN/NRR—2020/2090

ON THIS PAGE
Big bluestem (*Andropogon gerardii*) at Tallgrass Prairie National Preserve.
Photography by NPS

ON THE COVER
Cutting for removal of Osage orange (*Maclura pomifera*) in Tallgrass Prairie National Preserve.
Photography by NPS

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Abstract

Managers are challenged with the impact of problematic plants, including exotic, invasive, and pest plant species. Information on the abundance, distribution, and location of these plants is essential for developing risk-based approaches to managing these species. Based on surveys conducted in 2006, 2010, 2014, and 2018, Heartland Inventory and Monitoring Network staff and contractors identified a cumulative total of 33 problematic plant species in Tallgrass Prairie National Preserve. Of the 27 species found in 2018, we characterized 14 as very low frequency, 9 as low frequency, 4 as medium frequency, and 0 as high frequency. Only 4 (14.8%) of these species exceeded a 10-acre threshold. Smooth brome, widely planted in the bottomland prairies, is by far the most abundant problematic plant on the preserve. We recommend that preserve staff continue efforts to control the spread of old world bluestems and sericea in prairie to prevent further spread.

Introduction

The National Park Service's (NPS) management policies distinguish between native and exotic (i.e., non-native) plant species (NPS 2006). Exotic plant species are typically plants that were introduced by human actions, whether intentional or not. Invasive plants, following the definition used in Executive Order 13751, are those plants that are exotic and cause ecological or economic harm. Finally, pest plants are defined less by their biology and more by their context in the same way that the term *weed* is defined (NPS 2006). Pest plants, which include native species, interfere with a specific management objective, including protecting human health. We suggest thinking of this collection of exotic, invasive, and pest plants as *potentially problematic* species.

Park managers, however, are required to control only problematic plants that lead to *resource impairment*. For plant populations causing effects that fall short of the impairment threshold, park managers wield a high level of discretion in judging whether the population should be controlled or not. The standard for making this decision rests on five criteria: the origin of the species, prudence, feasibility, the harm (i.e., impact) that the plant causes to park resources, and the harm that removal causes (NPS 2006). As with impairment determinations, these decisions are based on professional judgment, environmental assessment, consultation with regulating agencies, evidence-based scholarship, subject matter expertise, and civic engagement with the public (NPS 2006).

This report presents results of problematic plant monitoring conducted at Tallgrass Prairie National Preserve over four periods between 2006 and 2018. The key metrics presented include plant abundance and geographic distribution within the park.

Spraying Johnsongrass (*Sorghum halepense*) at Tallgrass Prairie National Preserve.

Methods

Watch Lists

We searched for problematic plants on three watch lists. The prioritization for developing the lists is flexible and described in detail in Young et al. (2007). In general, the early detection watch list (n = 60; Table 1) is composed of prioritized problematic exotic plants not known to occur in the park based on NPSpecies (the national NPS database for plant occurrence registration). Prioritized problematic plants known to occur in the park based on NPSpecies constituted the park-established watch list (n = 30; Table 2). A third list, the park-based watch list, consisted of two native species that can invade prairie (n = 2, Table 3). Because our prioritization, NPSpecies, and botanical nomenclature are subject to periodic updating, in this report we included only plant species that we searched for in 2018 (Table 2). Of these, species that we did not search for during all of the previous survey periods are annotated in the tables. Although not on an official watch list, we also included Osage orange (*Maclura pomifera*), which was recorded during 2010 and 2018. While aquatic species were included on the watch lists, terrestrial plants were the focus of this survey. Aquatic plants were documented only occasionally.

Field Methods

We searched for problematic species on designated watch lists across Tallgrass Prairie National Preserve (Figure 1). Contractors conducted the surveys during September 19–29, 2006, and from August 16–September 5, 2010. Heartland Inventory and Monitoring Network staff conducted the survey with the assistance of one contractor and park staff during September 2–6, 2014, and with network staff only during August 20–24, 2018. In all cases, observers used GPS units to follow established transects (Figure 1).

Observers estimated plant cover in a 3- to 12-m belt, using the widest belt in which the observers were able to view plants. However, in 2006 only, the observer had the discretion to leave the search belt to find additional observations and target locations likely to support exotic plants (e.g., field edges and roads). Cover was estimated for each plant species within each transect using these cover values: 0 = 0, 1 = 0.1–0.9 m^2, 2 = 1–9.9 m^2, 3 = 10–49.9 m^2, 4 = 50–99.9 m^2, 5 = 100–499.9 m^2, 6 = 500–999.9 m^2, and 7 = 1,000–4,999.9 m^2. A total of 301 transects were surveyed in each survey year (Figure 1). While the intended length of each transect was 400 m, some transects (n = 59) were clipped at the park boundary. Average transect length in this study was 363.6 m.

Table 1. Early detection problematic plant watch list used to guide surveys in Tallgrass Prairie National Preserve.

Scientific Name	Common Name
Alnus glutinosa	European alder
Arundo donax	giant reed
Azolla spp.[a]	mosquitofern
Bassia scoparia	burningbush
Berberis thunbergii	Japanese barberry
Centaurea solstitialis	yellow star-thistle
Cirsium arvense	Canada thistle
Cynanchum louiseae[b]	Louise's swallow-wort
Dactylis glomerata[c]	orchardgrass
Daucus carota[b]	Queen Anne's lace
Dioscorea oppositifolia	Chinese yam
Dipsacus fullonum	Fuller's teasel
Dipsacus laciniatus	cutleaf teasel
Egeria densa[b]	Brazilian waterweed
Elaeagnus angustifolia	Russian olive
Euonymus fortunei[b]	winter creeper
Euphorbia cyparissias[b]	cypress spurge
Euphorbia esula	leafy spurge
Glechoma hederacea	ground ivy
Hemerocallis fulva[b]	orange daylily
Hesperis matronalis	dames rocket
Humulus japonicus[b]	Japanese hop
Iris pseudacorus[b]	paleyellow iris
Kochia scoparia	kochia
Leonurus cardiaca[b]	common motherwort
Lepidium latifolium[b]	broadleaved pepperweed
Lespedeza bicolor[b]	shrub lespedeza
Linaria vulgaris[b]	butter and eggs

[a] Searched for in 2014 and 2018 only.

[b] Searched for in 2010, 2014, and 2018 only.

[c] Searched for in 2006, 2014, and 2018 only.

Table 1 (continued). Early detection problematic plant watch list used to guide surveys in Tallgrass Prairie National Preserve.

Scientific Name	Common Name
Lonicera maackii	Amur honeysuckle
Lonicera tatarica	Tatarian honeysuckle
Lotus corniculatus	bird's-foot trefoil
Lotus tenuis	narrow-leaf bird's-foot trefoil
Lysimachia nummularia	creeping jenny
Lythrum salicaria	purple loosestrife
Myriophyllum aquaticum	parrot feather watermilfoil
Nasturtium microphyllum [b]	onerow yellowcress
Onopordum acanthium [b]	Scotch cottonthistle
Pastinaca sativa	wild parsnip
Phalaris arundinacea	reed canarygrass
Phragmites australis	common reed
Plantago lanceolata	narrowleaf plantain
Poa compressa	Canada bluegrass
Polygonum cuspidatum	Japanese knotweed
Populus alba	white poplar
Potamogeton crispus [b]	curly pondweed
Potentilla recta	sulphur cinquefoil
Prunus mahaleb [b]	Mahaleb cherry
Pueraria montana var. lobata	kudzu
Rhamnus cathartica [b]	common buckthorn
Rorippa officinale [a]	watercress
Rumex acetosella [b]	common sheep sorrel
Saponaria officinalis [b]	bouncingbet
Schedonorus arundinaceus	tall fescue
Schedonorus pratensis	meadow fescue
Securigera varia	crownvetch
Solanum dulcamara [c]	climbing nightshade
Sonchus arvensis [a]	field sowthistle
Tamarix ramosissima	saltcedar
Tanacetum vulgare [b]	common tansy
Vinca minor	common periwinkle

[a] Searched for in 2014 and 2018 only.

[b] Searched for in 2010, 2014, and 2018 only.

[c] Searched for in 2006, 2014, and 2018 only.

Table 2. Park-established problematic plant watch list used to guide surveys in Tallgrass Prairie National Preserve.

Scientific Name	Common Name
Ailanthus altissima	tree of heaven
Alliaria petiolata	garlic mustard
Arctium minus	lesser burdock
Bothriochloa bladhii	Caucasian bluestem
Bothriochloa ischaemum [a]	yellow bluestem
Bromus inermis	smooth brome
Bromus racemosus [b]	bald brome
Bromus tectorum	cheatgrass
Carduus nutans	nodding plumeless thistle
Centaurea stoebe ssp. *micranthos*	spotted knapweed
Cirsium vulgare	bull thistle
Elaeagnus umbellata [b]	autumn olive
Elymus repens [b]	quackgrass
Holcus lanatus	common velvetgrass
Hypericum perforatum [b]	common St. Johnswort
Lespedeza cuneata	sericea lespedeza
Lolium spp.[b]	ryegrass
Lonicera japonica	Japanese honeysuckle
Melilotus officinalis	yellow sweetclover
Morus alba	white mulberry
Poa pratensis	Kentucky bluegrass
Pyrus calleryana [a]	Callery pear
Rosa multiflora	multiflora rose
Rumex crispus [b]	curly dock
Sorghum halepense	Johnsongrass
Torilis arvensis [b]	spreading hedgeparsley
Torilis japonica	erect hedgeparsley
Typha angustifolia	narrowleaf cattail
Ulmus pumila	Siberian elm
Verbascum thapsus	common mullein

[a] Searched for in 2014 and 2018 only.

[b] Searched for in 2010, 2014, and 2018 only.

Table 3. Park-based problematic plant watch list used to guide surveys in Tallgrass Prairie National Preserve.

Scientific Name	Common Name
Juniperus virginiana	eastern redcedar
Robinia pseudoacacia	black locust

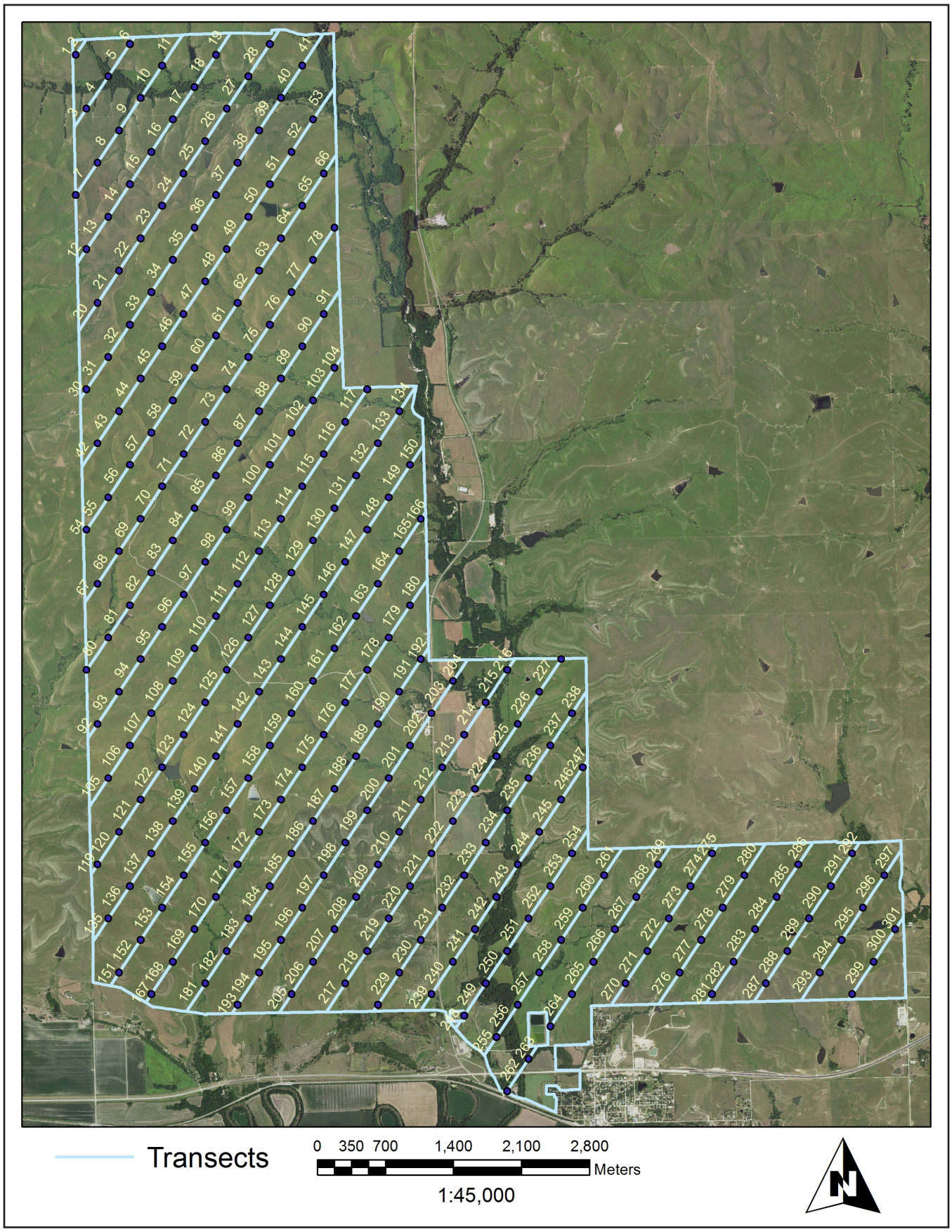

Figure 1. Location of transects used to monitor problematic plants in Tallgrass Prairie National Preserve.

Analytical Methods

We note an important assumption here with respect to the analytical methods: we treated all data similarly, which required the assumption that observations during 2006 were also made within a 3- to 12-m wide belt. This change should be considered when comparing metrics between 2006 and subsequent years.

A park-wide cover range was estimated for each problematic plant species encountered during each year. First, we calculated the minimum and maximum fraction of the park observed. To do this we used the distance between transects (400 m). The maximum fraction of the park observed assuming a 12-m belt was calculated as 12 m/400 m = 0.03, while the minimum fraction observed assuming a 3-m belt was 3 m/400 m = 0.0075.

To calculate the minimum of the estimated cover range for each species, the lower endpoints associated with the assigned cover class values for that species were summed and then divided by the reference frame fraction observed assuming the widest possible (12-m) survey belt (i.e., maximum fraction observed; Equation 1).

Equation 1:

$$\text{Minimum cover estimate} = \frac{\sum \text{low end of cover value range for species}}{\text{fraction of park observed assuming 12-m (max) belt width}}$$

Maximum cover for each species was calculated similarly, summing the upper endpoints of the cover values in each occupied search unit and assuming that a 3-m belt was surveyed (i.e., minimum fraction of area observed; Equation 2).

Equation 2:

$$\text{Maximum cover estimate} = \frac{\sum \text{high end of cover value range for species}}{\text{fraction of park observed assuming 3-m (min) belt width}}$$

Cover values were then converted from square meters to acres by multiplying each value by 0.000247105.

The park-wide frequency of problematic plants was calculated as the percentage of occupied search units (Equation 3). We treated all search units as equivalent for the purposes of frequency calculations.

Equation 3:

$$\text{Frequency of a problematic plant species} = \frac{\sum \text{search units occupied by species}}{\sum \text{search units surveyed}} \times 100$$

Taken together, the minimum and maximum cover estimates provided an estimated range of cover that accounts for the uncertainty arising from the sampling method. Non-overlapping ranges represent the strongest evidence for differences in abundance.

Finally, we created maps for each problematic plant species (not included in this report). The maps show occupied search units and the estimated cover value for each search unit during each survey period.

I-Ranks

The I-rank or invasive ranks are calculated using a standard protocol to assess the impacts of these plants (Morse et al. 2004). The I-ranks consist of four sub-ranks: ecological impact, current abundance/distribution, trend in distribution/abundance, and management difficulty. Because of their more direct implications for park management, the ecological impact and management difficulty sub-ranks, when available, are presented in Table 4 of the Results section (NatureServe 2018).

Taxonomic Notes

Certain species groups have likely resulted in conflated identifications over the course of the study. Patterns in the abundance and distribution for *Torilis arvensis* (spreading hedgeparsley) and *Torilis japonica* (erect hedgeparsley) may be best evaluated at the genus level. *Bromus racemosus* (bald brome) was included on watch lists during all surveys. We believe that the taxon, however, served as an umbrella for

specimens identified as *B. arvensis* (field brome), *B. japonicus* (Japanese brome), and *B. racemosus*. We have attempted to differentiate these specimens using our best judgement, and as of 2018 we narrowed the field to a choice between *B. arvensis* and *B. racemosus*. We differentiated between these using the following characteristics: *B. racemosus* has awns 5–9 mm long and straight or nearly so; *B. arvensis* has awns 7–13 mm long and curved, twisted, or bent outward (Yatskievych 1999). For the purposes of this study, these two species are also best evaluated as a single taxon.

Results and Discussion

Table 4 presents the plant abundance and frequency estimates in all survey years, and the 2018 data are depicted graphically using frequency and the midpoint of the abundance range (Figure 2). In Figure 2, we grouped plants in four categories: (1) very low frequency (≤2%, n = 3), (2) low frequency (>2–10 %, n = 7), (3) medium frequency (>10–40%, n = 4), and (4) high frequency (>40%, n = 10). While many factors impact our ability to control problematic plants, we use 10 acres as a guideline to identify lower and higher probability of successful control. A total of 85.2 % of species found in Tallgrass Prairie National Preserve fell below this threshold.

Tallgrass Prairie National Preserve supports low levels of a number of potentially problematic plants. Smooth brome (*Bromus inermis*), by far the most highly abundant plant in the park, occurs only in roughly 11% of transects. All of these occurrences are in areas planted in smooth brome. Other high abundance species include Eastern redcedar (*Juniperus virginiana*) and Osage orange (*Maclura pomifera*). Within the prairie, continuing to treat sericea lespedeza (*Lespedeza cuneata*) and old world bluestems (*Bothriochloa* spp.) on an early detection-rapid response basis appears to be the most important management strategy. Maps with plant locations and abundance are available for park use. These data are highly effective for early detection of problematic plants in the park. The extensive nature of this sampling design, however, may include high levels of unspecified observer error. Nevertheless, the data provide a generalized understanding of problematic plant abundance and distribution to effectively support problematic plant management decisions.

Table 4. Abundance and distribution of problematic plants found in Tallgrass Prairie National Preserve. Ecological impact (EI) and general management difficulty (Mgmt) are based on NatureServe I-Rank sub-ranks (Morse et al. 2004; NatureServe 2018). Sub-ranks are given as high (H), medium (M), low (L), insignificant (I), a range of these ranks, native, or not available (n/a).

Scientific Name	Common Name	EI	Mgmt	PeriodID	Frequency	Low Cover Estimate (acres)	High Cover Estimate (acres)
Ailanthus altissima	tree of heaven	M-L	M-L	2010	0.3	0.001	0.030
Ailanthus altissima	tree of heaven	M-L	M-L	2014	1.0	0.010	0.385
Ailanthus altissima	tree of heaven	M-L	M-L	2018	1.3	0.100	2.326
Alliaria petiolata	garlic mustard	M-L	M	2006	1.7	0.115	2.949
Alliaria petiolata	garlic mustard	M-L	M	2010	2.7	0.281	6.267
Alliaria petiolata	garlic mustard	M-L	M	2014	1.0	0.017	0.682
Alliaria petiolata	garlic mustard	M-L	M	2018	0.7	0.002	0.059
Arctium minus	lesser burdock	L-I	M-I	2006	1.0	0.002	0.089
Arctium minus	lesser burdock	L-I	M-I	2010	0.7	0.002	0.059
Bothriochloa bladhii [a]	Caucasian bluestem	n/a	n/a	2010	0.3	0.008	0.326
Bothriochloa bladhii [a]	Caucasian bluestem	n/a	n/a	2014	2.0	1.013	20.737
Bothriochloa bladhii [a]	Caucasian bluestem	n/a	n/a	2018	5.3	0.473	10.622
Bothriochloa ischaemum [a]	yellow bluestem	n/a	n/a	2014	0.7	0.016	0.652
Bothriochloa ischaemum [a]	yellow bluestem	n/a	n/a	2018	0.3	0.008	0.326
Bromus arvensis	field brome	n/a	n/a	2010	35.5	32.654	524.960
Bromus arvensis	field brome	n/a	n/a	2014	11.0	1.528	26.414
Bromus arvensis	field brome	n/a	n/a	2018	10.6	0.115	4.507
Bromus inermis	smooth brome	M	M-L	2006	7.0	32.066	572.555
Bromus inermis	smooth brome	M	M-L	2010	9.0	82.781	1546.821
Bromus inermis	smooth brome	M	M-L	2014	9.6	103.133	1795.864
Bromus inermis	smooth brome	M	M-L	2018	10.6	88.884	1604.792
Bromus racemosus	bald brome	n/a	n/a	2006	14.0	11.598	224.925
Bromus racemosus	bald brome	n/a	n/a	2018	33.6	1.332	24.938

[a] Searched for in 2014 and 2018 only.

[b] Searched for in 2010, 2014 and 2018 only.

[c] Searched for in 2010 and 2018 only.

Table 4 (continued). Abundance and distribution of problematic plants found in Tallgrass Prairie National Preserve. Ecological impact (EI) and general management difficulty (Mgmt) are based on NatureServe I-Rank sub-ranks (Morse et al. 2004; NatureServe 2018). Sub-ranks are given as high (H), medium (M), low (L), insignificant (I), a range of these ranks, native, or not available (n/a).

Scientific Name	Common Name	EI	Mgmt	PeriodID	Frequency	Low Cover Estimate (acres)	High Cover Estimate (acres)
Cardus nutans	nodding plumeless thistle	M-I	H-M	2014	0.3	0.001	0.030
Centaurea stoebe ssp. *micranthos*	spotted knapweed	M	H-L	2006	0.3	0.001	0.030
Cirsium vulgare	bull thistle	M-L	M-L	2006	1.0	0.017	0.682
Cirsium vulgare	bull thistle	M-L	M-L	2010	2.3	0.432	4.062
Cirsium vulgare	bull thistle	M-L	M-L	2014	1.3	0.003	0.119
Cirsium vulgare	bull thistle	M-L	M-L	2018	1.3	0.018	0.712
Cynanchum louiseae [b]	Louise's swallow-wort	H-M	H	2014	0.3	0.001	0.030
Cynanchum louiseae [b]	Louise's swallow-wort	H-M	H	2018	1.0	0.002	0.089
Elymus repens [b]	quackgrass	M-L	H-M	2010	0.3	0.001	0.030
Elymus repens [b]	quackgrass	M-L	H-M	2018	0.7	0.002	0.059
Hypericum perforatum [b]	common St. Johnswort	M-L	M	2010	0.3	0.082	1.644
Hypericum perforatum [b]	common St. Johnswort	M-L	M	2018	0.3	0.008	0.326
Juniperus virginiana	eastern redcedar	native	native	2006	2.3	0.028	1.097
Juniperus virginiana	eastern redcedar	native	native	2010	1.7	0.264	5.585
Juniperus virginiana	eastern redcedar	native	native	2014	2.3	0.110	2.712
Juniperus virginiana	eastern redcedar	native	native	2018	5.0	1.043	21.894
Lespedeza cuneata	sericea lespedeza	M-L	M-L	2014	0.3	0.082	1.644
Lespedeza cuneata	sericea lespedeza	M-L	M-L	2018	1.7	0.512	5.618
Lolium spp.	ryegrass	n/a	n/a	2006	1.0	0.173	3.614
Lonicera japonica	Japanese honeysuckle	M	H-M	2014	0.3	0.008	0.326
Maclura pomifera [c]	osage orange	M-L	L	2010	5.6	1.618	18.526
Maclura pomifera [c]	osage orange	M-L	L	2018	5.3	4.724	45.579

[a] Searched for in 2014 and 2018 only.

[b] Searched for in 2010, 2014 and 2018 only.

[c] Searched for in 2010 and 2018 only.

Table 4 (continued). Abundance and distribution of problematic plants found in Tallgrass Prairie National Preserve. Ecological impact (EI) and general management difficulty (Mgmt) are based on NatureServe I-Rank sub-ranks (Morse et al. 2004; NatureServe 2018). Sub-ranks are given as high (H), medium (M), low (L), insignificant (I), a range of these ranks, native, or not available (n/a).

Scientific Name	Common Name	EI	Mgmt	PeriodID	Frequency	Low Cover Estimate (acres)	High Cover Estimate (acres)
Melilotus officinalis	sweetclover	M	M	2006	0.7	0.009	0.356
Melilotus officinalis	sweetclover	M	M	2010	3.3	0.142	3.987
Melilotus officinalis	sweetclover	M	M	2014	0.3	0.001	0.030
Melilotus officinalis	sweetclover	M	M	2018	2.0	0.027	1.067
Morus alba	white mulberry	M-L	M-L	2006	1.0	0.091	2.000
Morus alba	white mulberry	M-L	M-L	2010	2.3	0.432	4.062
Morus alba	white mulberry	M-L	M-L	2014	2.7	0.837	16.974
Morus alba	white mulberry	M-L	M-L	2018	2.7	0.199	4.652
Nasturtium officinale[b]	watercress	M-L	MI	2014	0.3	0.082	1.644
Poa pratensis	Kentucky bluegrass	M	M-L	2010	7.3	0.693	16.105
Poa pratensis	Kentucky bluegrass	M	M-L	2014	0.7	0.413	3.321
Poa pratensis	Kentucky bluegrass	M	M-L	2018	4.7	0.019	0.712
Pyrus calleryana[a]	Callery pear	L-I	M-L	2006	0.3	0.082	1.644
Pyrus calleryana[a]	Callery pear	L-I	M-L	2010	0.3	0.082	1.644
Pyrus calleryana[a]	Callery pear	L-I	M-L	2014	0.3	0.008	0.326
Robinia pseudoacacia	black locust	H-M	M	2006	0.3	0.082	1.644
Robinia pseudoacacia	black locust	H-M	M	2010	0.3	0.008	0.326
Robinia pseudoacacia	black locust	H-M	M	2018	0.7	0.083	1.674
Rosa multiflora	multiflora rose	L	L	2014	1.0	0.413	3.351
Rosa multiflora	multiflora rose	L	L	2018	0.3	0.001	0.030
Rumex crispus[b]	curly dock	L-I	M-L	2010	20.3	0.339	10.079
Rumex crispus[b]	curly dock	L-I	M-L	2014	5.0	0.190	4.267
Rumex crispus[b]	curly dock	L-I	M-L	2018	14.6	0.207	4.830

[a] Searched for in 2014 and 2018 only.

[b] Searched for in 2010, 2014 and 2018 only.

[c] Searched for in 2010 and 2018 only.

Table 4 (continued). Abundance and distribution of problematic plants found in Tallgrass Prairie National Preserve. Ecological impact (EI) and general management difficulty (Mgmt) are based on NatureServe I-Rank sub-ranks (Morse et al. 2004; NatureServe 2018). Sub-ranks are given as high (H), medium (M), low (L), insignificant (I), a range of these ranks, native, or not available (n/a).

Scientific Name	Common Name	EI	Mgmt	PeriodID	Frequency	Low Cover Estimate (acres)	High Cover Estimate (acres)
Schedonorus phoenix	tall fescue	M	H-M	2011	4.7	2.580	47.134
Schedonorus phoenix	tall fescue	M	H-M	2014	4.3	2.275	41.537
Schedonorus phoenix	tall fescue	M	H-M	2018	3.3	0.545	6.952
Sorghum halepense	Johnsongrass	M-L	H-M	2006	4.0	0.947	14.787
Sorghum halepense	Johnsongrass	M-L	H-M	2010	2.3	1.269	21.096
Sorghum halepense	Johnsongrass	M-L	H-M	2014	2.0	1.409	23.406
Sorghum halepense	Johnsongrass	M-L	H-M	2018	3.0	0.844	7.383
Torilis arvensis[b]	spreading hedgeparsley	n/a	n/a	2010	7.0	1.314	17.887
Torilis arvensis[b]	spreading hedgeparsley	n/a	n/a	2014	1.3	0.577	6.609
Torilis arvensis[b]	spreading hedgeparsley	n/a	n/a	2018	3.0	0.185	4.089
Torilis japonica	erect hedgeparsley	n/a	n/a	2006	2.3	0.050	1.987
Torilis japonica	erect hedgeparsley	n/a	n/a	2018	0.3	0.008	0.326
Typha angustifolia	narrowleaf cattail	H-M	M	2006	1.0	0.025	0.979
Typha angustifolia	narrowleaf cattail	H-M	M	2014	0.7	0.825	16.500
Typha angustifolia	narrowleaf cattail	H-M	M	2018	0.7	0.091	1.970
Ulmus pumila	Siberian elm	M-L	M-L	2014	2.7	0.036	1.423
Ulmus pumila	Siberian elm	M-L	M-L	2018	4.0	0.106	2.563
Verbascum thapsus	common mullein	M-L	L	2014	1.0	0.084	1.703
Verbascum thapsus	common mullein	M-L	L	2018	0.7	0.002	0.059

[a] Searched for in 2014 and 2018 only.

[b] Searched for in 2010, 2014 and 2018 only.

[c] Searched for in 2010 and 2018 only.

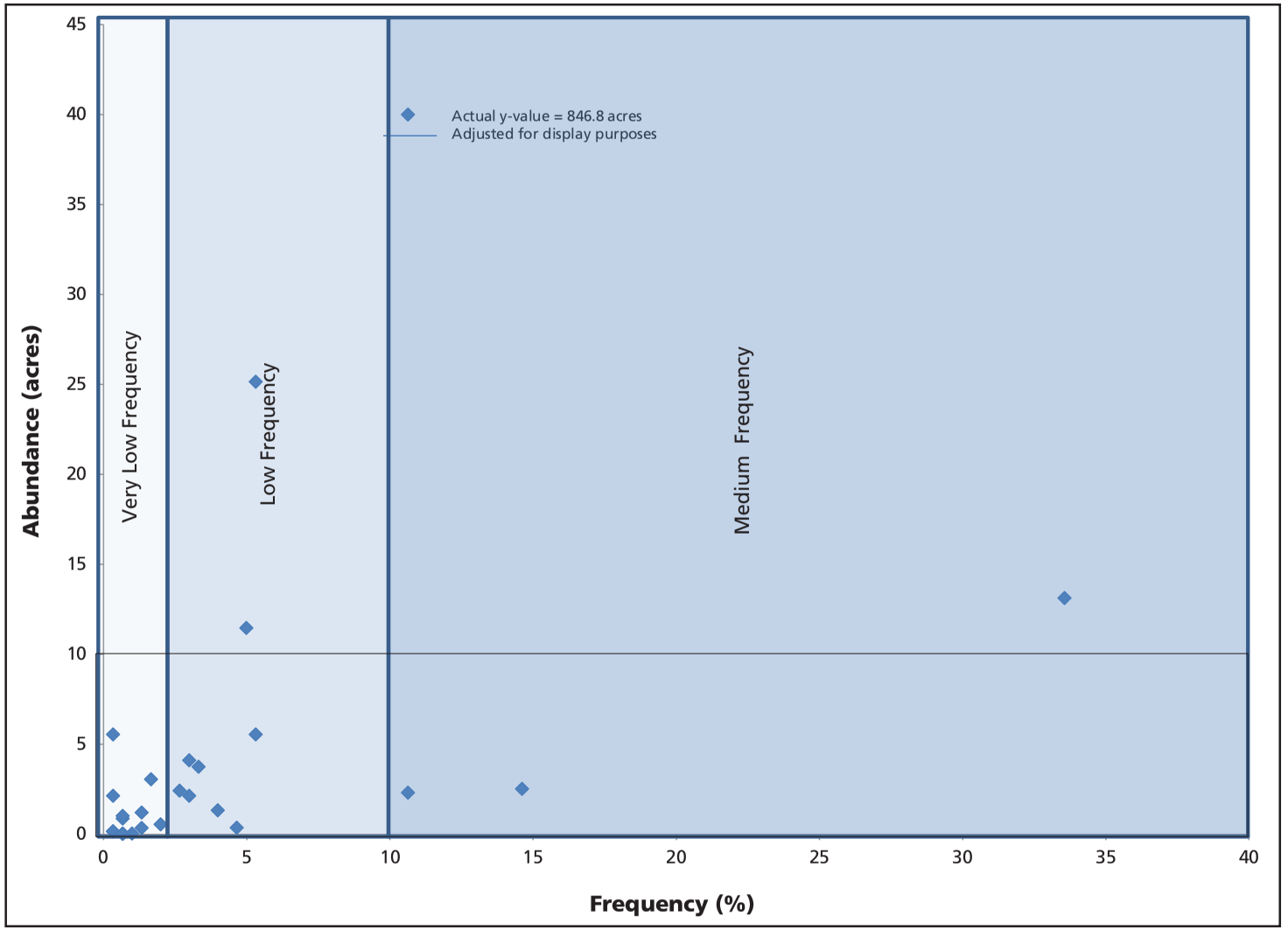

Figure 2. 2018 problematic plant frequency and abundance relationship at Tallgrass Prairie National Preserve. The abundance measure used is based on the mid-point of the abundance range. Plants are categorized into four categories: very low frequency (≤2%), low frequency (>2–10%), medium frequency (>10–40%) and high frequency (>40%). The horizontal line marks the 10-acre threshold at which successful control of a plant becomes less likely. Species in ascending order of frequency include *Rosa multiflora*, *Bothriochloa ischaemum*, *Hypericum perforatum*, *Torilis japonica*, *Alliaria petiolata*, *Elymus repens*, *Verbascum thapsus*, *Robinia pseudoacacia*, *Typha angustifolia*, *Cynanchum louiseae*, *Cirsium vulgare*, *Ailanthus altissima*, *Lespedeza cuneaae*, *Melilotus officinalis*, *Morus alba*, *Torilis arvensis*, *Sorghum halepense*, *Schedonorus phoenix*, *Ulmus pumila*, *Poa pratensis*, *Juniperus virginiana*, *Bothriochloa bladhii*, *Maclura pomifera*, *Bromus arvensis*, *Bromus inermis*, *Rumex crispus*, and *Bromus racemosus*.

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